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ABSTRACT

Two parallel studies investigated the influence of principle-based and attribute-based similarity relations on new category learning by preschoolers. One of two possible functions of a single novel artifact (which differed between studies) was modeled for children and practiced by children. Children then judged which test objects received the same name as the original. Test objects were either globally similar or dissimilar in appearance from the original. These objects were designed in such a way that each could be inferred to afford only one of the two possible functions. A total of 16 preschool children participated in each study. Findings indicated that patterns of categorization depended on which original function had been experienced. It is concluded that categorization into newly learned categories may activate self-initiated, principle-based reasoning in young children. However, categorization was also influenced by overall similarity. The finding that preschoolers' categorization and naming are consistently influenced by functional information came as a surprise in light of previous research efforts. (Author/RH)

Principle-Based Inferences in Preschoolers' Categorization of Novel Artifacts[1]

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Abstract. Two parallel studies investigated the influence of principle-based inferences and attribute-based similarity relations on new category learning by preschoolers. One of two possible functions of a single novel artifact (which differed between studies) was modeled for and practiced by children, who then judged which test objects got the same name as the original. Test objects, either globally similar or dissimilar in appearance from the original, were designed such that each could be inferred to afford only one of the two possible functions. (Actual functions of the test objects were not directly observable.) Patterns of categorization depended on which original function had been experienced. So, categorization into newly learned categories may activate self-initiated, principle-based reasoning in young children. Still, categorization was also influenced by overall similarity.

Categorization by adults often involves knowledge-based reasoning instead of pure attribute matching. That is, principle-based inferences may override or modify the contribution of similarity relations (e.g., Medin, 1989). Categorization in the child is more likely to be grounded in the atheoretic apprehension of similarity. Still, some researchers have argued that if one looks in the right conceptual domains (i.e., where youngsters have some principled knowledge) and in a sensitive way, one can reveal principle-driven inferences even in young children's categorization (e.g., Keil, 1989; Gelman, 1988; Gelman & Markman, 1986). The current work goes beyond children's reasoning about already familiar concepts to test for self-initiated, principle-based inferences in their acquisition of new categories.

Two parallel studies involved learning novel artifact categories. Children engaged in semi-naturalistic interaction with a single, named category member, whose function was demonstrated. Then, they judged the category membership of test instances varying orthogonally in their degree of "unprincipled" similarity to the standard and in the degree to which they could be inferred to function as the standard. (Actual functions of the test objects were not directly observed.)

[1]Presented at the Meetings of the Society for Research in Child Development, Seattle, WA. (April, 1991).

[2]At the time of the research, these co-authors were Swarthmore College students, most of them undertaking the work to fulfill a requirement in a Seminar in Developmental Psychology, under the supervision of the first author. We express our appreciation to Don Reynolds for his remarkable ability to translate our outlandish ideas into real, functioning stimulus objects. Our thanks also to the staff and children at Trinity Cooperative Day Nursery and Swarthmore Presbyterian Nursery Day School.

Given the difficulty of establishing that "unprincipled similarity" varies independently of functional affordance, the experimental design in both studies was as follows: The standard object could have two very different functions, and complementary groups of children experienced each of them. Each test object was designed with features to support positive inferences about one function and negative inferences about the other. Hence, different test patterns should emerge in the two groups if spontaneous principled (i.e., function-relevant) inferences are mediating categorization.

Experiment 1

Method

Subjects. Sixteen children participated in the study. Their mean age was 5 yrs, 5 mos, with a range of 4 yrs, 6 mos to 6 yrs, 10 mos. All were attending a suburban preschool. Eight children were assigned to the Roller group and 8 to the Color-Changer group.

Materials. The original object was a transparent, two-chambered plexiglass cylinder with a handle, which could be used to (a) roll designs on playdough, or (b) transform the color of water (which could be passed between chambers).

Of the 8 test objects, 4 were designed to look globally similar to the original and 4 were designed to look more dissimilar. Within each set, 2 could function as rollers, but not as color-changers, and 2 could function as color-changers, but not rollers. For example, for one Similar, Color-Changer test object, the handle was attached directly to the plexiglass cylinder such that the object could not function as a Roller, but easily afforded the color-changing function. For one Dissimilar, Roller test object, the plexiglass cylinder was replaced with a solid wooden one of exactly the same shape, but which could not be filled with water to perform the Color-Changer function.

Ratings of adults confirmed that the 4 test objects designated as Similar "looked more similar" to the original object than the 4 designated as Dissimilar.

Procedure. Each child was exposed either to the Roller function or to the Color-Changer function of the original object--never both. The object was introduced as a "bindle,--something that my friend asked me to show to children at your school." The experimenter modeled and described the bindle's function while repeatedly using its name. The child was told: "Let me show you what I can do with this bindle," but the functional information was not given as an explicit definition of the name of the kind. To demonstrate the function in the Roller condition, the experimenter held the object by the handle and rolled out designs on a sheet of playdough. In the Color-changer condition, the object was set into a stand, and colored water was poured into the upper chamber; then, a controller was pulled, allowing the water to flow into the bottom chamber, where it mixed with food coloring and changed color.

Following the experimenter's demonstration, the child was encouraged to try the bindle out, if necessary with the experimenter's help. Each child was exposed to one and only one function.

After the child's semi-naturalistic interaction with the object, the experimenter removed it from view, and then, one at a time, brought out each of the test objects. The child was told: "My friend also sent these other things. I think that some of them are bindles and some of them are not bindles. I'd like you to tell me what you think." For each object, the experimenter asked: "Do you think that this is a bindle or that it's not bindle?" Each time, the child was allowed to inspect the object, but was firmly discouraged from trying it out.

For each child, the first sub-block of four test objects consisted of 2 similar and 2 dissimilar items; in each case, one of the two afforded the Roller function and one afforded the Color-changer function. The original object itself was queried on the fifth test trial, followed by a brief opportunity to use the object again. Then, the remaining 4 test objects were presented in series. Across subjects, each test object occurred equally often in the first and second sub-block. The order of objects within each test sub-block was randomly determined for each subject, except that, due to an administrative error, the two similar objects were presented prior to the two dissimilar objects.

Following the 9 test trials, the experimenter re-presented each of the 8 test objects in the same order. After reminding the subject of his or her previous categorization decision, the experimenter asked the child to explain it. (Analyses of these explanations are not included in the current report. However, in the very few cases in which the child changed his or her categorization decision for an object during this phase, the final decision was used in the analyses of the data reported here.)

Results and Discussion

All subjects judged that the original object was a member of the kind, i.e., was a "bindle", when it was queried during the test phase.

With regard to categorization of the test objects, Figure 1 shows the proportion of responses that constituted acceptances of the objects as a "bindle". These proportions are computed separately for each exposure group (Roller or Color-Changer), according to whether the objects were globally Similar or Dissimilar to the original object, and according to whether the objects could be inferred to function as the original object had. Each proportion is based on 8 subjects, each contributing two responses. Slince the same physical objects served as the stimuli for the two exposure groups, but the demonstrated function of the original object differed, the +Function test objects for one group served as the -Function test objects for the other group.

As Figure 1 depicts, the children's categorization decisions were affected by the objects' functional affordances. Overall, +Function objects were accepted 72% of the time as members of the kind, whereas -Function objects were accepted 39% of the time. Eleven of 16 subjects were more likely to accept +Function than -Function objects, and no subject showed the opposite pattern. Moreover, 7 of the 8 distinct physical objects were more likely to be accepted as category members when they were +Function than when they were -Function. The exception was one of the Similar objects, and indeed, as can be seen in Figure 1, the effect of functional affordance tended to be far more marked for the Dissimilar objects. It is noteworthy that not a single Dissimilar object was ever included in the category when the original functional affordance was eliminated, but these same objects were accepted over 50% of the time when the functional affordance was preserved. The uniform tendency to reject Dissimilar, dysfunctional objects is also the primary basis for the effect of object similarity: By contrast, to the total lack of acceptances of Dissimilar, dysfunctional objects, Similar, dysfunctional objects were accepted 78% of the time.

Thus, in Experiment 1, there seems to be very clear evidence that preschool children's categorization into new artifact kinds is based on principled reasoning about whether the object can function as the original object does. Additionally, there is a suggestion that such reasoning comes into play particularly when the new object is not too similar in appearance to the original. However, the latter effect must be interpreted with a good deal of caution, given the methodology of Exp. 1. It seems unlikely, but not impossible, that the unintended procedure of presenting Similar objects on average earlier in the test phase than Dissimilar objects was alone responsible for the trend. A more plausible possibility is that the particular ways that functions were undermined in the Similar

objects were less well understood by the children than the means used to undermine functions in the Dissimilar objects. Thus, global similarity per se may not have been the source of the effect.[3]

Experiment 2 was partially designed to address these alternative accounts. Not only was the order bias eliminated, but the Similar and Dissimilar objects were matched for the particular way in which functional affordance was undermined for the -Function conditions. In addition, Exp. 2 provided the opportunity to test the generality of the main finding of Exp. 1, that preschoolers' category learning is guided by spontaneous inferences about object function.

Experiment 2

Method

Subjects. Sixteen children participated in the study. Their mean age was 4 yrs, 8 mos, with a range of 3 yrs, 9 mos to 5 yrs, 5 mos. Thus, they were somewhat younger than the children of Exp. 1. All were attending a suburban preschool, and none had participated in the previous expriment. Eight children were assigned to the Painter group and 8 to the Instrument group.

Materials. The original stimulus was a T-shaped metal object with attached brushes and wires which could be used as a Painter to paint four parallel lines or could be used as a musical Instrument when three tunable strings were plucked.

As in Exp. 1, 8 test objects were designed such that each object afforded one and only one of the possible functions of the original. Here, we employed more systematic means for eliminating functions, and used the same means for a matched pair of Similar and Dissimilar test objects. For one pair of +Painter/- Instrument objects, the metal strings were absent. For the other such pair, the strings were embedded in one of the objects' handles such as to be virtually impossible to pluck. For one pair of -Painter/+Instrument objects, the paintbrushes were absent. For the other such pair, the brushes were placed in locations that made it impossible to paint with them. Within all pairs, degree of similarity was manipulated by modifying or not modifying essentially non-functional properties of the objects. So, for example, one Similar object looked just the original except that strings of beads replaced the paintbrushes. For the Dissimilar object in that pair, not only were the brushes replaced, but also the object was entirely different in shape and color; the strings and tuners were mounted on a green rectangular frame.

Procedure. Each child was exposed either to the Painter function or to the Instrument function of the original object--never both. The object was introduced as a "stennet,--something that my friend asked me to show to children at your school." The experimenter modeled and described the stennet's function while repeatedly using its name. The child was told: "Let me show you what I can do with this stennet," but, as in Exp. 1, the functional information was not given as an explicit definition of the name. To demonstrate the function in the Painter condition, the experimenter brought out a stand with four paint jars of different colors, and a large piece of blank paper. The experimenter then dipped the stennet into the paint and made a design. Subsequently, the child was encouraged to paint his or her own designs. To demonstrate the function in the Instrument condition, the experimenter brought out a guitar pick and plucked out a simple melody. The child

[3]Follow-up questioning of many of the subjects in Exp. 1 discredited the additional possibility that these children responded as they did to the Similar objects simply because they did not notice that the objects differed from the original at all.

was subsequently encouraged to produce melodies of his or her own. The semi-naturalistic interaction in this phase lasted for approximately 3 minutes, and was followed immediately by the test phase.

The test phase was exactly parallel to Exp. 1, save for remedying the inadvertent procedural error of presenting Similar objects earlier in each sub-block than Dissimilar objects. In Exp. 2, the order of test objects within a sub-block was randomly determined for each subject.

Results and Discussion.

All subjects judged that the original object was a member of the kind, i.e., was a "stennet", when it was queried during the test phase.

With regard to categorization of the test objects, Figure 2 shows the proportion of responses that constituted acceptances of the objects as a "stennet". These proportions are shown separately for each exposure group (Painter or Instrument), according to whether the objects were globally Similar or Dissimilar to the original object, and according to whether the objects could be inferred to function as the original object had. Each proportion is based on 8 subjects, each contributing two responses. Since the same physical objects served as the stimuli for the two exposure groups, but the demonstrated function of the original object differed, the +Function test objects for one group served as the -Function test objects for the other group.

As Figure 1 depicts, the children's categorization decisions were mediated by inferences about the objects' functional affordances. Overall, +Function objects were accepted 68% of the time as members of the kind, whereas -Function objects were accepted only 28% of the time. Twelve of the 16 subjects accepted more +Function than -Function objects, and only one showed the reverse pattern. Moreover, every one of the 8 physical objects was accepted more often by the group for whom the original function was afforded than the group for which it was not.

The similarity of the test object to the original had a less consistent effect. Overall, 55% of the Similar objects were accepted, compared to 42% of the Dissimilar objects. Unlike Exp. 1, there was no hint that the effect of functional affordance was stronger for the Dissimilar than for the Similar objects. If anything, the effect was more consistent here for the Similar objects, but an extensive follow-up study, using these same stimuli with larger numbers of subjects (Kemler Nelson, in preparation) suggests that effects of functional affordance and global similarity are additive. Thus, it is probable that the appearance of an interaction between similarity and functional affordance in the first experiment was due to confounded differences in the means by which functional affordance was manipulated. When functional affordance is eliminated in the same way in Similar-looking and Dissimilar-looking test objects, it seems to have equal impact on the child's decision-making--although global similarity counts as a smaller and independent factor (Kemler Nelson, in preparation).

General Discussion.

We have reported two studies that offer compelling evidence that spontaneous inferences about function mediate category learning about novel artifacts by children. These demonstrations that preschoolers' categorization and naming is consistently influenced by functional information come as some surprise in light of previous research efforts that have found little evidence that it plays such a role (e.g., Gentner, 1978; Tomikawa & Dodd, 1980). In fact, on one important count, the current test for the importance children attribute to functional information is far more demanding than the previous tests they have "failed". The positive demonstration here is particularly

remarkable because it emerges in a context in which children--on their own initiative--must infer whether or not a test object has a certain functional affordance. In much previous work where preschoolers have ignored functional information in categorization, the functional information was directly provided to them at the time of generalization.

Why, then, do the children in the current study appear to be so much more systematically principled in their categorization than their agemates in previous research? We believe that the most crucial aspects of our test were (a) the design of objects whose functional affordances (and disabilities) were related in a nonarbitrary manner to their perceptible attributes, and (b) where the causal links between structure and function were simple to understand. This is a context in which children have some principled background knowledge (about physical causality) that they can readily bring to bear. Apparently, learning about a new artifact kind is sufficient motivation to them to activate that knowledge and to reason from it.

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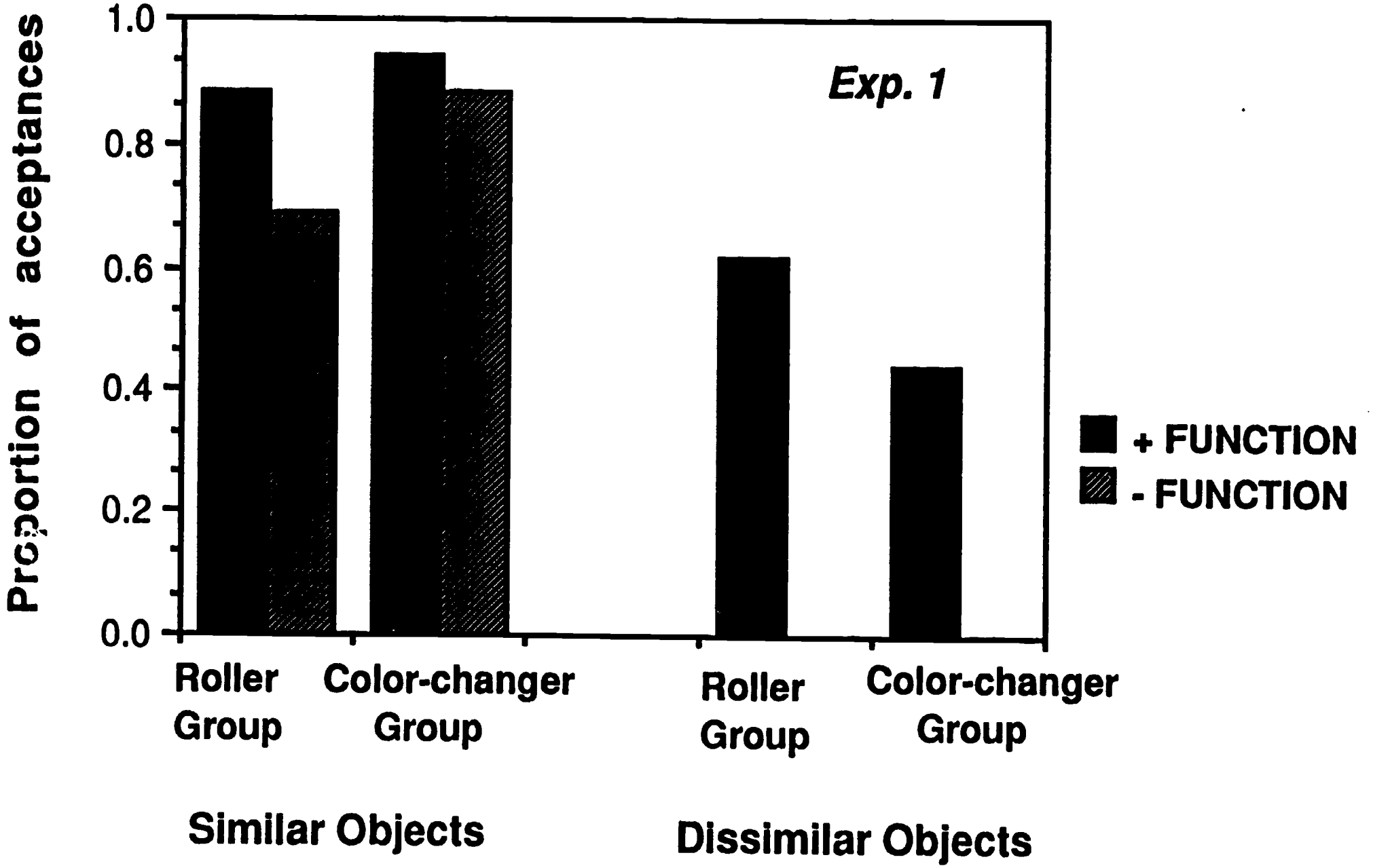
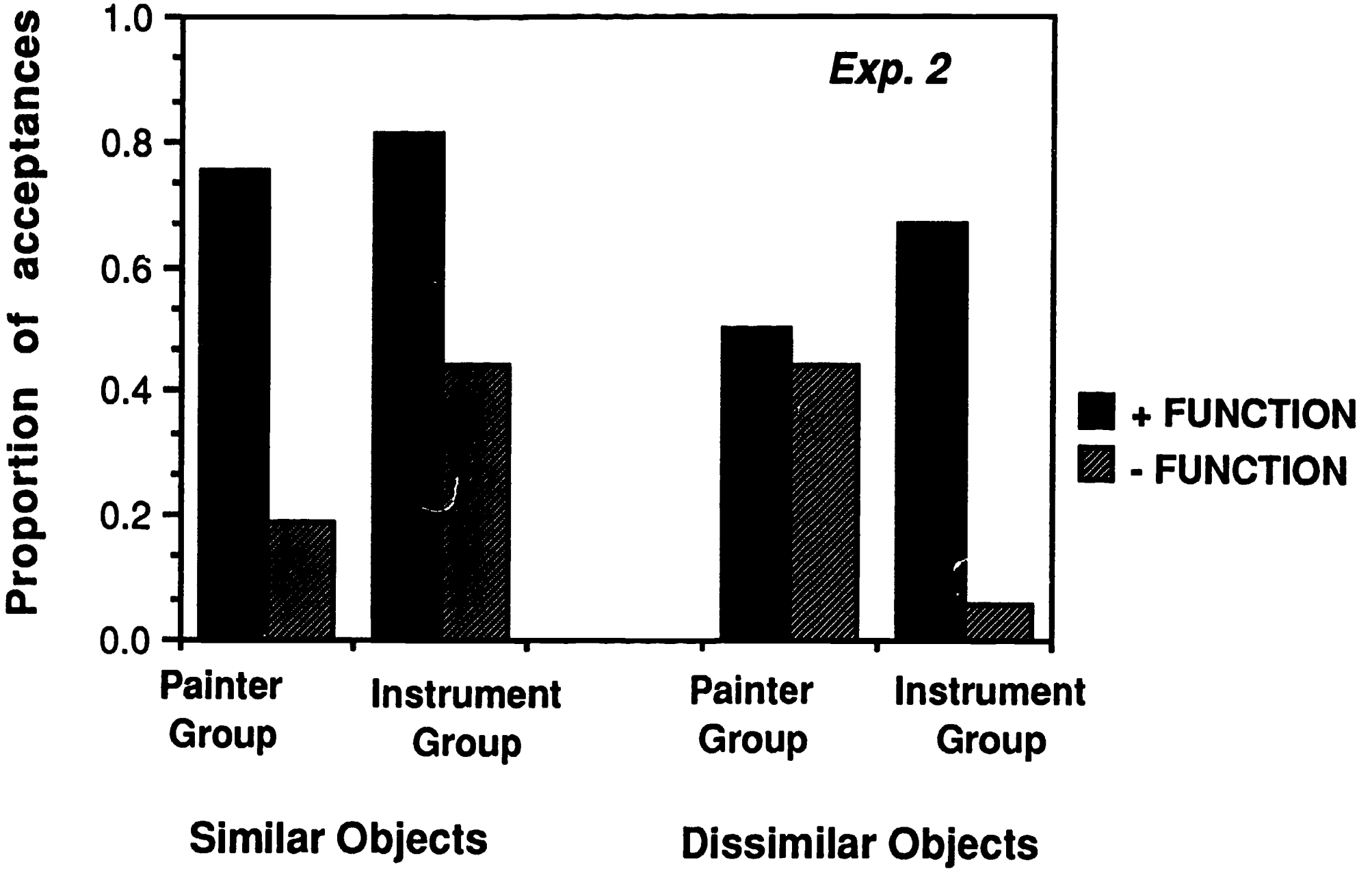
Figure Captions

Figure 1. Generalization patterns in Experiment 1. For each exposure group, the proportion of acceptances of test objects as members of the category, according to whether they were globally similar or dissimilar from the standard, and according to whether they could be inferred to function as the standard had. The + Function test objects for one group served as the - Function test objects for the other group.

Figure 2. Generalization patterns in Experiment 2. For each exposure group, the proportion of acceptances of test objects as members of the category, according to whether they were globally similar or dissimilar from the standard, and according to whether they could be inferred to function as the standard had. The + Function test objects for one group served as the - Function test objects for the other group.


Exp. 1
Proportion of acceptances
1.0
0.8
0.6
0.4
0.2
0.0
+ FUNCTION
- FUNCTION
Roller Group
Color-changer Group
Roller Group
Color-changer Group
Similar Objects
Dissimilar Objects


Exp. 2
Proportion of acceptances
1.0
0.8
0.6
0.4
0.2
0.0
+ FUNCTION
- FUNCTION
Painter Group
Instrument Group
Painter Group
Instrument Group
Similar Objects
Dissimilar Objects